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The Mysteries of Real Materials

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5th Ablation Workshop
Lexington, KY

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Current and Future Efforts*



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- Significant interest in community to develop/introduce models for:
 - Pyrolysis gas and surface ablation chemistry governed by reaction kinetics
 - Surface catalysis
 - Coupling surface ablation chemistry with CFD
 - Surface roughness and mass injection effects
 - In-depth radiation transport
 - Others?
- Issues:
 - Acquiring the data necessary to support model development and validation requires sophisticated experiments and diagnostics
 - The number and availability of test facilities (e.g., arc jets) capable of simulating environments of interest is very limited
 - The potential for model validation with data from instrumented flight experiments is highly unlikely
- Acquiring the resources (\$\$\$) to support advanced model development will require a favorable cost-benefit demonstration

*"Ablator Modeling: Why Not Much Has Changed Over the Past 45+ Years," B. Laub, 4th AF/SNL/NASA Ablation Workshop, Albuquerque, NM, March 1-3, 2011.

Unanticipated material failure mode

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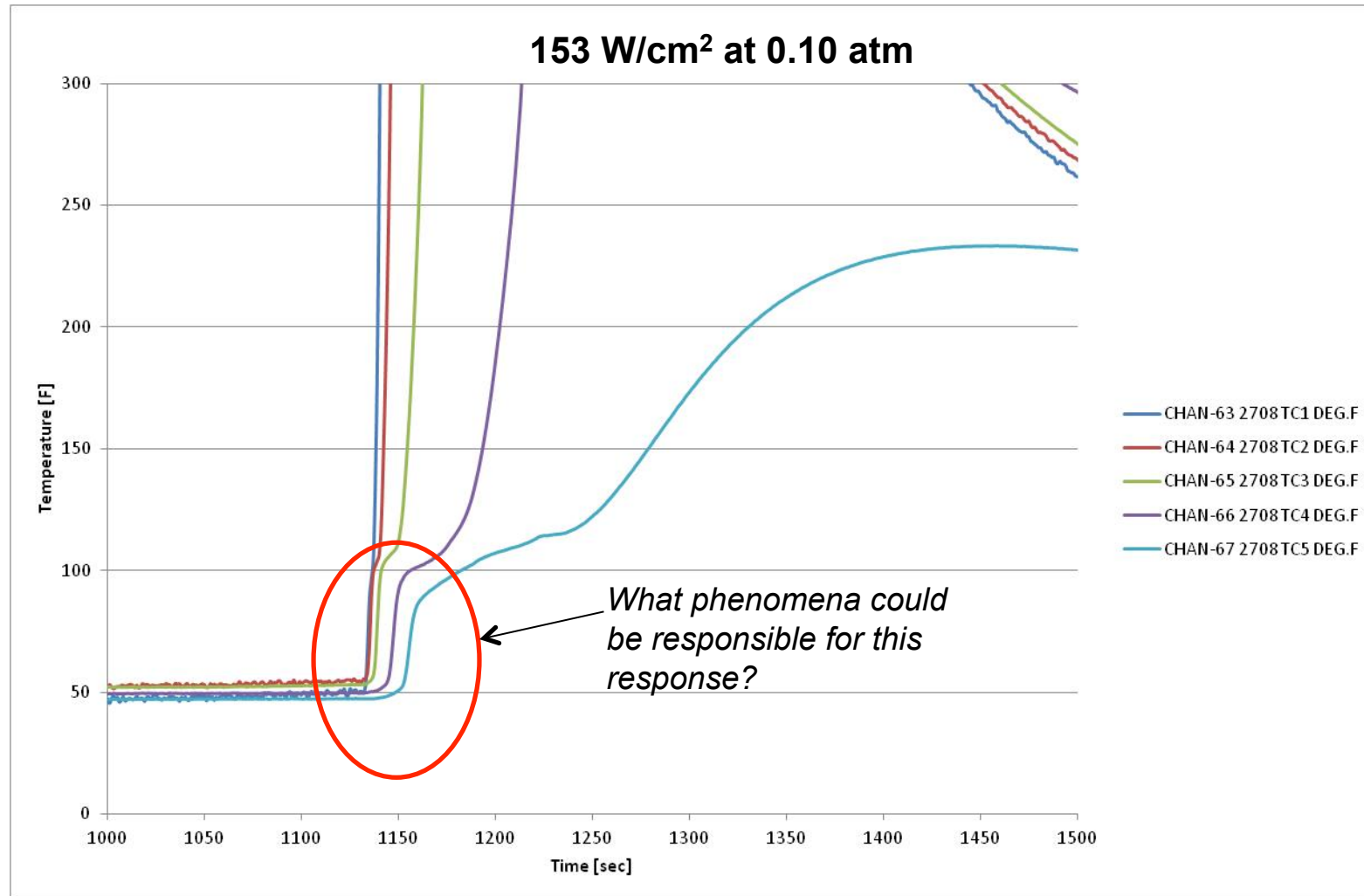
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Unusual thermocouple response

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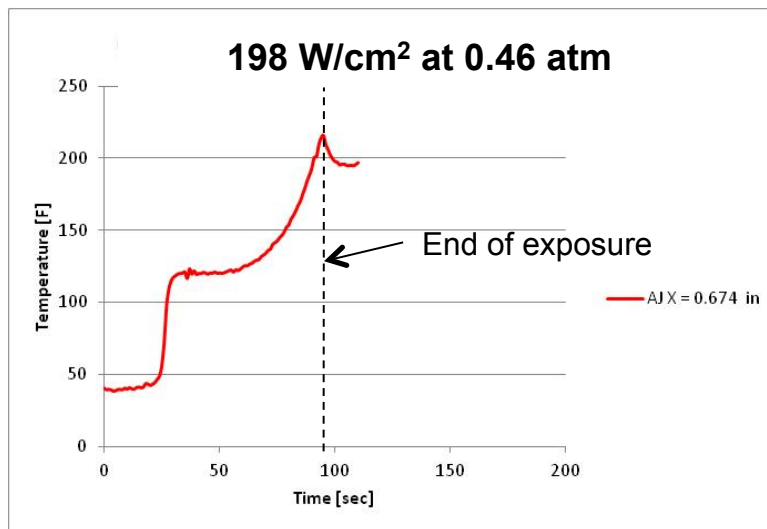
Consistent arc jet test data



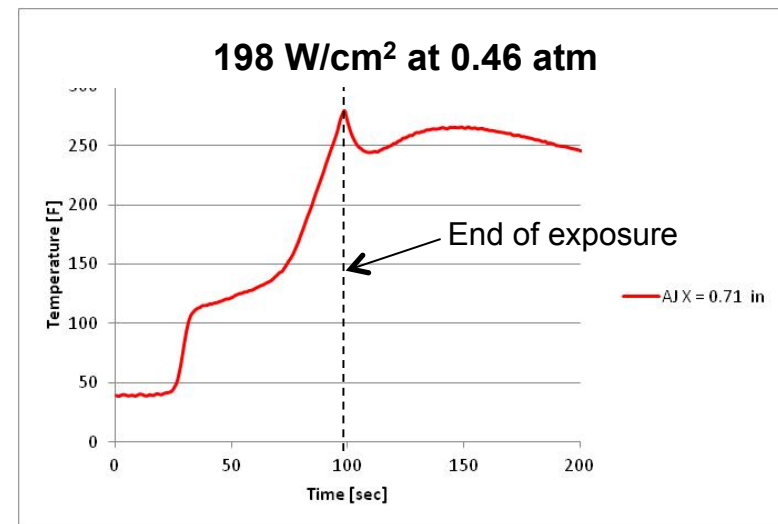
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Two different tests; identical conditions; initial rise dependent upon T/C depth; “plateau” exhibits slight dependency on stagnation pressure



T/C at 0.674" from surface



T/C at 0.710" from surface



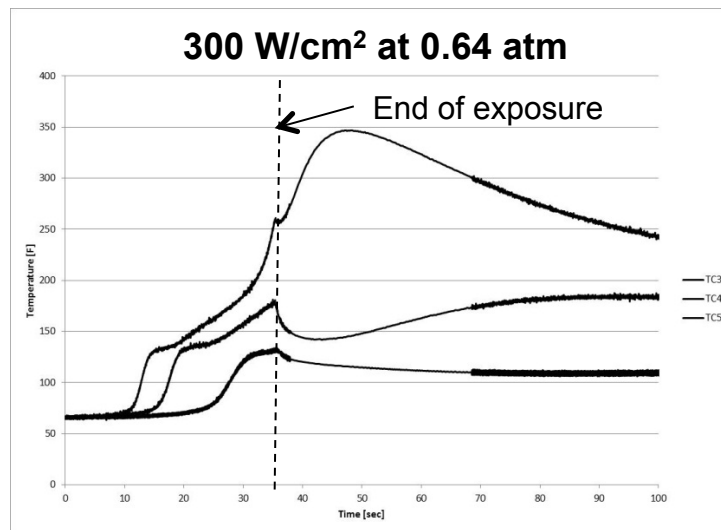
More arc jet test data



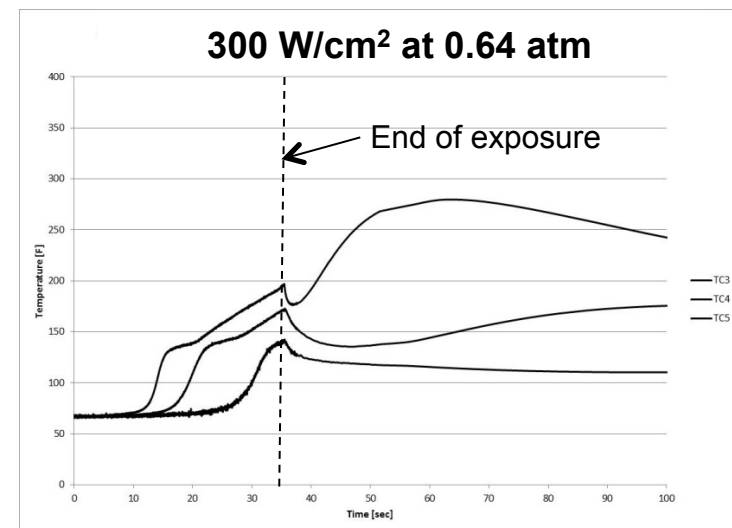
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Two different tests; identical conditions; initial rise dependent upon T/C depth; “plateau” exhibits slight dependency on stagnation pressure



TC3 at 0.50" from surface (nominal)
TC4 at 0.60" from surface (nominal)
TC5 at 0.80" from surface (nominal)



TC3 at 0.50" from surface (nominal)
TC4 at 0.60" from surface (nominal)
TC5 at 0.80" from surface (nominal)



Test with CO₂ laser (10.6 μm)

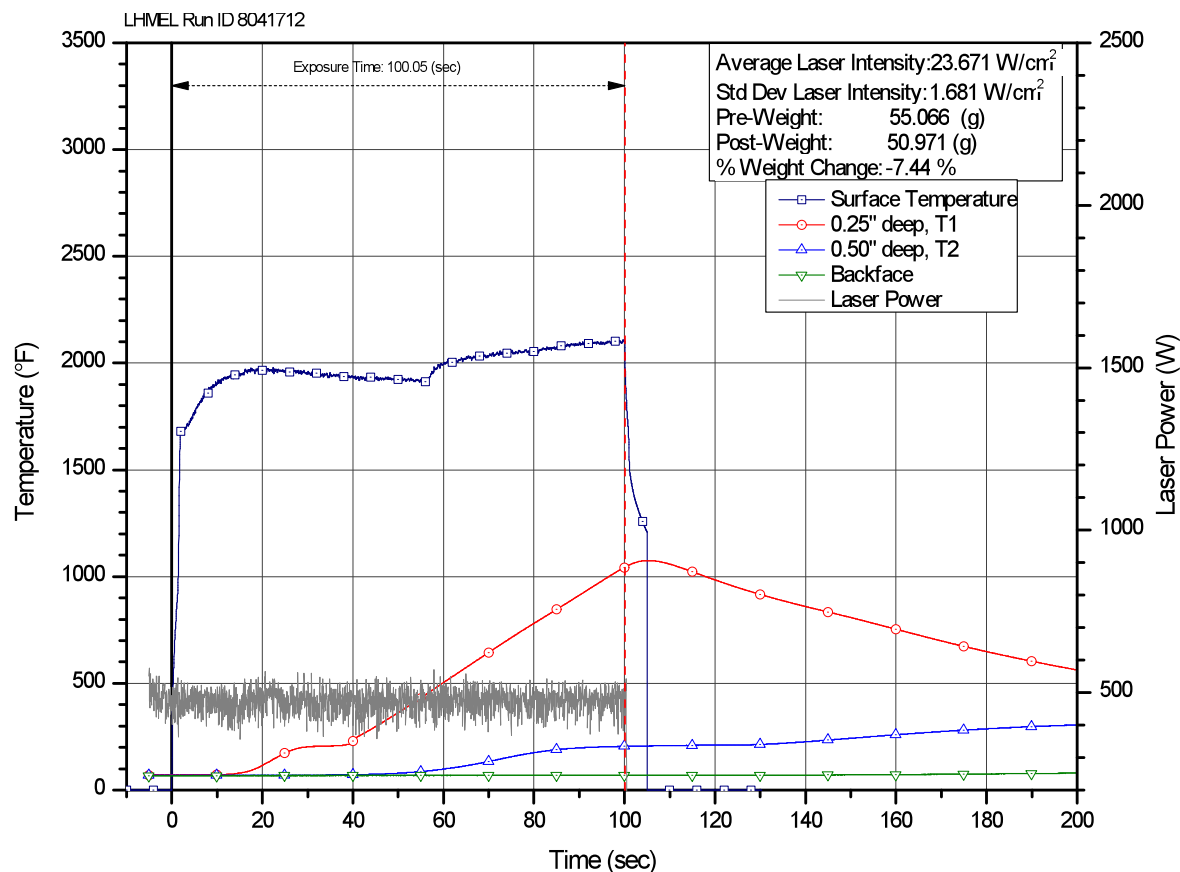


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100 s exposure to CO₂ laser at 1 atm (24 W/cm²)

Note: initial response appears normal; “plateau” still present





Another test with CO₂ laser

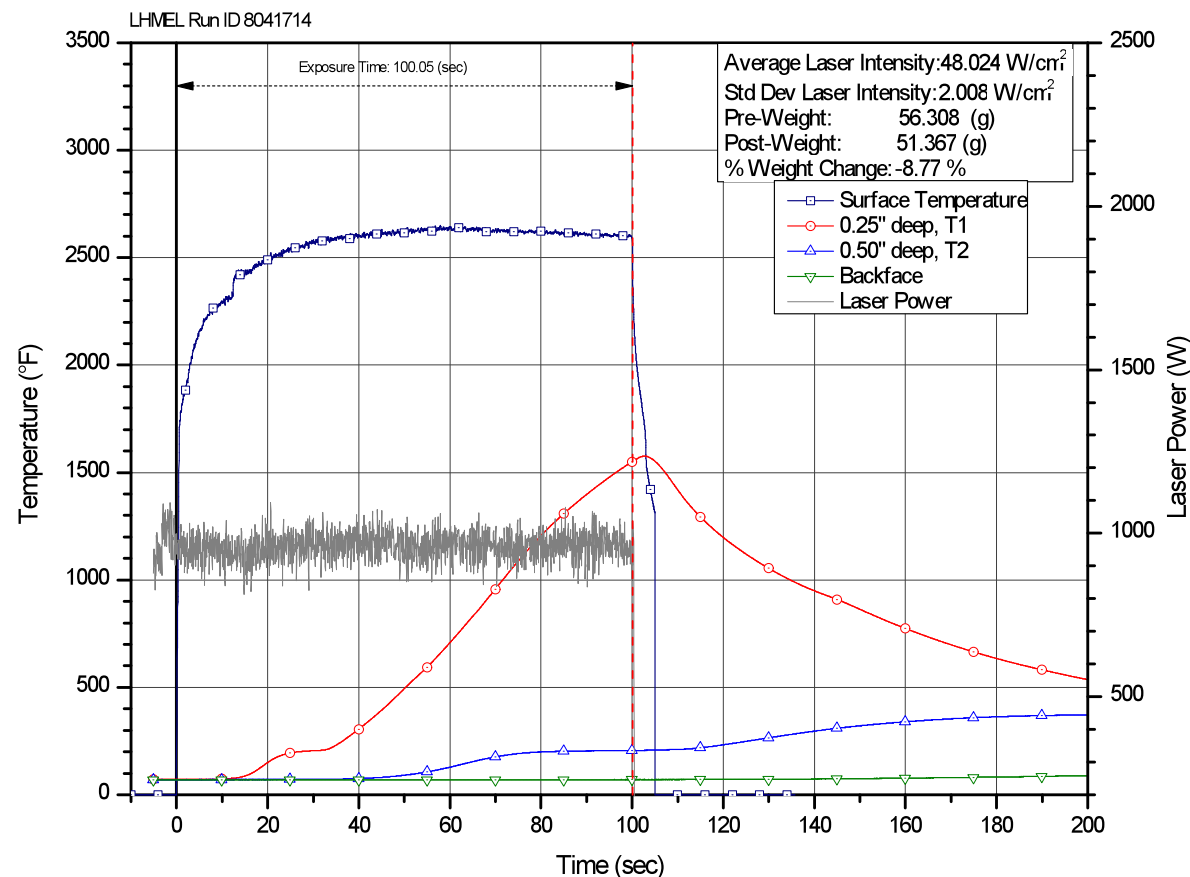


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100 s exposure to CO₂ laser at 1 atm (48 W/cm²)

Note: initial response appears normal; “plateau” still present





Summary



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- Designing a TPS should require an understanding of potential failure modes (requires extensive testing)
 - Unfortunately, limited resources typically restrict studies of TPS failure mechanisms and limits
 - Consequently, if failure is observed (particularly if the mechanism is not understood), the material is not used
- TPS sizing typically involves defining thickness required to limit the interface (bondline) temperature between the material and the underlying structure
 - If all material response mechanisms are not being modeled, the maximum bondline temperature cannot be predicted with accuracy
 - Typical ground tests are at constant conditions whereas the flight environment experiences time-dependent conditions
 - Even if all mechanisms were understood and modeled, validating the model in ground test is challenging